USE OF HIGH PERFORMANCE LIQUID CHROMATOGRAPHY TO DETERMINE AQUEOUS CONSTITUENT CONCENTRATIONS

PROCEDURE ID: YMP-LBNL-TIP/AFT 9.0 | REV.1, MOD. 0 | EFFECTIVE: 08/25/2000

1. PURPOSE

This Technical Implementing Procedure (TIP) describes the methods used to determine the concentration of aqueous constituents in liquid samples using High Performance Liquid Chromatography (HPLC) at Lawrence Berkeley National Laboratory (LBNL) for supporting the Yucca Mountain Site Characterization Project (YMP).

2. SCOPE

This procedure applies to all YMP-LBNL personnel (or contractor personnel following LBNL procedures) involved in the use of HPLC to determine concentrations of constituents in solutions for YMP activities subject to Quality Assurance Requirements and Description (QARD), DOE/RW-0333P. Prior to conducting work described in Section 3 of this procedure, personnel performing measurements, require training to this procedure.

All technical activities, data collected using this procedure, and any instrument calibrations shall be in accordance with this TIP and in full compliance with YMP Administrative Procedure (YAP)-12.3Q, *Control of Measuring and Test Equipment and Calibration Standards*. All documentation resulting from actions taken under this TIP will be recorded in the scientific notebook and/or the Equipment Logbook (controlled as a supplemental record to the scientific notebook) as described in the Office of Civilian Radioactive Waste Management (OCRWM) Administrative Procedure (AP)-SIII.1Q, *Scientific Notebooks*.

If this procedure cannot be implemented as written, YMP-LBNL personnel shall notify the responsible Principal Investigator (PI) or designee. If it is determined that a portion of the work cannot be accomplished as described in this TIP, or would produce undesirable results, that portion of the work shall be stopped and not resumed until this procedure is modified per YMP-LBNL-QIP-5.2, *Preparing Development Plans & Quality /Technical Implementing Procedures*.

If the responsible PI or designee determines that a modification or a revision to the TIP would cause an unreasonable delay in proceeding with the task, then an expedited change to the procedure, including documentation of deviation from the approved procedure, can be made according to YMP-LBNL-QIP-5.2. Such changes are subject to

review, usually after the task has proceeded, and thus work performed under TIPs with expedited changes is done at risk of future invalidation.

Employees may use a controlled electronic or hard copy of this procedure; however, employees are responsible for assuring that the correct revision of this procedure is used. When this procedure becomes obsolete or superseded, it must be destroyed or marked "superseded" to ensure that this document is not used to perform work in accordance with YMP-LBNL-QIP-6.0, *Document Control*.

3. PROCEDURE

3.1 Principle

Chromatography is a separation method that relies on differences in partitioning behavior between a flowing mobile phase and a stationary phase to separate the components in a mixture. A column holds the stationary phase and the mobile phase carries the sample through it. Sample components that partition strongly into the stationary phase move more slowly through the column and are separated from components that primarily stay in the mobile phase and pass through the column. As components elute from the column a detector can quantify their concentration.

Liquid chromatography (LC) uses a liquid as the mobile phase to carry the components of the mixture through the column. LC is usually carried out at room temperature and can be used for thermally labile and nonvolatile components. LC only requires that the component be slightly soluble in the liquid phase. For sensitive detectors, LC is frequently based on ultraviolet-visible (UV-VIS) and fluorescence signals.

HPLC is one form of LC that utilizes high-pressure pumps to increase the efficiency of the separation. Normal-phase HPLC uses a polar stationary phase and a nonpolar organic solvent, such as n-hexane or chloroform, as the mobile phase. Reverse-phase HPLC uses a relatively nonpolar stationary phase and a polar mobile phase, such as methanol, acetonitrile, water, or mixtures of these solvents. Reverse-phase chromatography is the most common form of liquid chromatography, primarily due to the wide range of analytes that can dissolve in the mobile phase.

3.2 Equipment

The TIP user is expected to have a basic understanding of the chromatography principle and be familiar with the instruction manual of the particular HPLC system that is used for sample analysis.

In general, the HPLC system consists of a reservoir of mobile phase, a pump, an

injector, a separation column, and a detector. Solvents must be degassed to minimize formation of bubbles. The pumps provide a steady high pressure without pulsing, and can be used to control and vary the composition of the solvent during the course of the separation. The liquid sample is introduced into a sample loop by injection. The presence of analytes in the column effluent is recorded by detecting a change in UV-VIS absorption and/or fluorescence after excitation with a suitable wavelength. A data acquisition program of commercial software supplied by the manufacturer is an integral part of the instrument. An autosampler is an optional item that provides automatic analyses of samples on a predetermined schedule.

Labware used in this procedure shall be washed in the appropriate cleaning solution (e.g., LIQUI-NOX phosphate-free liquid detergent), rinsed three times with tap water, rinsed three times with reagent water, and air-dried at room temperature.

3.3 Samples

Liquid samples may be from various sources, including (but not limited to) laboratory and field tracer work. Samples shall be controlled in accordance with YMP-LBNL-QIP-SII.0, *Documenting Sample Control*.

3.3.1 Sample Name/Bottle Labeling

Samples for chemical analysis shall be collected in the appropriate containers (e.g., high-density polyethylene and/or glass bottles with tight sealing caps) deemed suitable for collection and storage of samples. In general, sample collection process is simply to transfer some volumes of sample from the sample source. Care shall be taken (e.g., wear gloves) to prevent cross-contamination during sample collection. Each sample shall be given a unique identifier to reflect the sample source or an appropriate abbreviation thereof. Sample names shall be marked with an indelible marker either directly on the bottle or on an adhesive sticker affixed to the bottle along with the name of the originator and the date. The sample name, time and location of sample collection, and the unique identifier assigned by the Sample Management Facility (SMF) of the YMP (if applicable), in accordance with YAP-SII.1Q *Submittal, Review, and Approval of Requests for Yucca Mountain Site Characterization Project Geologic Specimens*, shall be entered into the scientific notebook.

Safety considerations associated with handling of chemicals will depend on the chemical nature of the constituents in the solutions. Material Safety Data Sheets (MSDSs) shall be consulted to determine whether special protective clothing and/or eye protection are required. A hazard label shall be placed on any sample bottle that contains hazardous chemicals.

3.3.2 Sample Handling/Preservation

For samples collected from the laboratory work, they shall be refrigerated before analysis. For samples collected from field sites, refrigeration after sample collection and during sample transfer to the LBNL may not be feasible. Dependent upon the characteristics of the samples, alternative steps (e.g., as putting the ice packs together with the samples during sample storage and transfer) shall be taken, at the discretion of the responsible PI or designee, to mitigate potential sample degradation. The method of preservation shall be recorded in the scientific notebook.

Samples shall be stored such that the impact of storage on the analyses is minimized. For example, if a light-sensitive constituent is to be analyzed (e.g., a fluorescent dye such as fluorescein), the samples shall be stored in darkness and/or in opaque bottles. Special handling requirements for different constituents shall be considered on an individual basis. Such special handling steps shall be recorded in the scientific notebook.

With the above stated sample handling requirements, samples shall be analyzed within three months of collection. If samples cannot be analyzed within this timeframe, they shall be analyzed at the first available opportunity, and a notation shall be placed in the scientific notebook identifying the duration (obtained from sample collection date recorded on the collection bottle, and the analysis date) samples have exceeded the analysis timeframe. An analysis of the data applicability shall be documented in the scientific notebook.

3.4 Implementing Procedure

3.4.1 Identification of Standards to be Used

In accordance with YAP-12.3Q, the Measuring and Test Equipment (M&TE) Justification form (Attachment 1) shall be filled out for each standard used and filed in the scientific notebook.

A. NIST-traceable standards: the calibration standards, when available, shall be traceable to nationally recognized standards [e.g., National Institute of Standards and Technology (NIST)], and procured from YMP-approved contractors on the Qualified Suppliers List (QSL), or an alternative approach within an Activity Evaluation shall be pursued according to AP-2.21Q, *Quality Determinations and Planning for Scientific, Engineering and Regulatory Compliance Activities*.

B. Non-NIST-traceable standards: under most circumstances for HPLC, NIST-traceable standards are not available or cannot be obtained within the holding time of necessary measurement. In such cases, high-purity chemicals, such as reagent grade chemicals that conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society (ACS) (American Chemical Society

Specifications, 8th edition, 1993), shall be used as the "standards" and the ratio approach described below will be used.

Approaches using ratios shall be employed to present the qualified data when non-NIST-traceable "standards" are used. Such approaches are appropriate to the laboratory and/or field tracer tests, where relative comparison may be sufficient. For example, the measured instrument response of the collected sample is divided by the response of the released tracer sample, with the instrument responses obtained using the "standards" (see Section 3.4.2 for preparation of "standards"). In employing this ratio approach, the chemicals used for the released samples (therefore, the collected samples) in the tracer tests and used for making "standards" shall be from the same chemical source (e.g., the same bottle).

With the ratio approach, the ratio results obtained are independent of the purity (as well as sources) of chemicals used. Such approaches will limit the applicability of data, however, as only the relative comparison (i.e., the ratio value, instead of the absolute amount/concentration of the analyte) is obtained. Such approach, if used, shall be documented in the scientific notebook.

If NIST-traceable standards become available and can be obtained within the holding time of the samples, comparison runs shall be performed between the non-NIST-traceable and the NIST-traceable standards, with explanation of these results and acceptability of results described in the scientific notebook. If the non-NIST-traceable "standards" are acceptable, the absolute amount/concentration of the analyte generated based on such "standards" will be regarded as being qualified.

3.4.2 Preparation of Standard Solutions

A. Starting standards shall be either (1) obtained by purchasing the NIST-traceable stock solutions with their concentrations stated (e.g., 1,000 mg/L) (see Section 3.4.1A), or (2) prepared by using chemicals (See Section 3.4.1B), a calibrated analytical balance, and calibrated volumetric glassware (discussed after in this subsection).

Obtain the starting "standard" solution(s) by weighing an amount of chemical and dissolving it in a known amount of water. Usually, concentrations of 1,000 mg/L and/or 100 mg/L for the "standards" are good working starting solutions. When weighing the amount of chemical standard, avoid using small weights close to the balance precision. If the chemical has low aqueous solubility (e.g., 70 mg/L), choose the concentration of the starting "standard" solution that is close (but still lower than) to the solubility limit (e.g., 50 mg/L) and use relatively large volume of water (e.g., 0.05 g chemical dissolved

in 1 L water, instead of 0.005 g chemical dissolved in 0.1 L water). Record the chemical weight and liquid volume in the scientific notebook.

Calibrate the balance in accordance to YMP-LBNL-TIP/AFT-1.0, *Balance Calibration*. Verify the accuracy of volumetric flasks, pipettes and pipettors by weighing water quantities delivered (pipettes, pipettors) or contained (flasks) using a calibrated balance. Discard flasks, pipettes and pipettors that show larger than 1% of its nominal volume.

B. Use serial dilution technique, a widely recognized and accepted method of preparing standards, to obtain a set of standard solutions that span the expected range of concentrations in the samples or the instrument response. For each dilution step, use the pipette and/or pipettor to take the appropriate volume of concentrated stock solution into a volumetric flask and fill the reagent water to the calibration line of the flask. Mix the solution thoroughly. Repeat the dilution step until the desired concentration is obtained. For example, pipet 10 ml of 100 mg/L stock solution into a 100 ml volumetric flask and fill with reagent water to the flask to produce the 10 mg/L standard solution.

To obtain mixtures of standards containing several analytes, which are also suitable for calibration, pipet a certain volume of each stock analyte standard solution into a volumetric flask and fill the water to the calibration line of the flask. For example, pipet 25 ml of 100 mg/L solution separately for four analyte standards into a 100 ml volumetric flask and fill with reagent water to the flask; this will produce a mixture of standards with 25 mg/L concentration each for these four analytes.

Record in the scientific notebook steps taken to make serial dilution, i.e., the volume pipetted and size of volumetric flasks. For preparing the mixture standards (if applicable), record the volumes of each analyte in the scientific notebook.

C. Prepare a label indicating the chemical's name and concentration, preparation date, preparer's initial, and attach the label to the individual container of standard solutions.

3.4.3 Preparatory Verification

The TIP user is expected to have a basic understanding of the chromatography principle and be familiar with the instruction manual of the particular HPLC system that is used for sample analysis. Documentation of the following steps is not necessary unless malfunctions

are detected. If this should occur, suspend the operation until the malfunction is corrected.

- Energize the system components.

- Degas the solvent to remove dissolved gases for approximately ten minutes by bubbling helium gas through the solvent reservoirs. The approach of vacuum degassing is also acceptable to achieve the same purpose.

- Load the data acquisition program that is a part of the equipment. Make sure that the whole system is not leaking by visual checking and/or observing the pressure indications in the instrument, and the data acquisition program is responsive.

- Warm up the instrument for at least half an hour before calibration and sample measurement.

3.4.4 Sample Introduction

If using an autosampler, transfer an aliquot of solution (e.g., standards and samples) into clean vials for measurement, with each vial uniquely labeled to ensure the traceability to the source solutions. Place the vials in sequence in the carousel, enter the sample identifications and other operating conditions (e.g., run time, injection volume) in the equipment's scheduler.

3.4.5 Calibration and Sample Measurement Method

A. Calibrate the instrument by conducting measurements on a series of standard solutions that span the expected range of concentrations of the samples. Refer to Section 3.4.2 for preparation of standard solutions.

Obtain a response (peak area or height) for each standard using the data acquisition system of the instrument, and then use these responses to construct a calibration curve. A minimum of four concentrations for standard solutions is required to establish the calibration curve. Software available with the instrument may calculate the curve and the correlation coefficient (R^2); or use the built-in functions of commercial software (e.g., MS Excel) to perform the calculation. In order for the calibration curve to be acceptable, the R^2 must be equal to or greater than 0.998. If the data does not meet this criterion, take actions to correct the problems [e.g., rerun or remake the standard(s), check/modify the experimental conditions, check the instrument]. Record calibration information (including date, time, identity of standard solutions, and responses) in the scientific notebook.

Perform the calibration each day when samples are analyzed. Calibrate the instrument at the beginning, and at the end of sample measurement or at intervals determined by the PI or designee based on experience with the instrument. Record the results of all calibrations and the times when they were done in the scientific notebook (refer to Section 3.4.11).

B. Once the calibration curve has been established, initiate the measurement of samples and record results in the scientific notebook. Depending upon the constituent concentration present in the samples, dilute samples appropriately until the final solution measurement falls within the calibration curve. Record all dilutions, if applicable, in the scientific notebook. Use the calibration curve to determine the concentrations of samples given their responses.

3.4.6 General Considerations

The following considerations are common to HPLC usage.

A. Filtration

If the samples contain suspended particulate matter (e.g., liquid observed to be turbid), filter the samples prior to introducing them to the instrument. Filtration can be accomplished by any means that does not introduce interfering contamination or cross-contamination between samples or alter the concentration of the target species. Choose filtration media and labware to avoid sorption of constituents of interest. For example, Nalgene Analytical Filter Unit (< 0.45 μm) is one of the choices for sample filtration. Document the method and materials in the scientific notebook.

B. Dilution

Depending upon the analyte concentration present in the samples, dilute samples appropriately until the final solution measurement falls within the response range of the calibration curve. Do not deduce the sample concentrations by extrapolating the calibration curve. Document the dilution information in the scientific notebook.

C. Instrument Drift

To evaluate the instrument's stability, repeat measurements on a given solution (standard or sample) at least twice over the course of all measurements. Conduct duplicate sample analysis at a frequency of at least 1 in 10 samples.

In cases where instrument drift occurs, the PI or designee shall

decide about the correction method or whether measurements need to be repeated. Document the method of accounting for drift the scientific notebook.

(1) Average two successive calibration curves that indicate drift (i.e., the response of each standard at each time is used to generate an "averaged" calibration curve).

(2) Interpolate the standard response by assuming that the drift is linear with time (or sample analysis sequence). For example, if a standard has a response of 50.0 and 55.0 before and after a sample is measured, and the sample is the 4th of 10 samples measured between these two standards, then the proper standard response to calculate the sample concentration will be 50.0 + (4 / 10) (55.0 - 50.0) = 52.0.

D. Temperature Operation Conditions

Ensure that the instrument, samples, and standard solutions are conditioned to the same room temperature.

3.4.7 Documentation of Sample Measurement Results

Document the following information in the scientific notebook for each set of measurements:

- the unique identifier of the instrument used (e.g., manufacturer's name, model number, and serial number),
- the operating method (e.g., column, mobile phase, injection volume, run time, detector wavelength, autosampler sequence),
- calibration and sample analysis results (including information about sample identities, concentration and time of standard solutions that were run). Enter them into a spreadsheet file for simple calculations (e.g., using the built-in functions of MS Excel).

3.4.8 Identification of Calibration Intervals

Calibration shall be performed each day samples are analyzed (Section 3.4.5).

3.4.9 Identification of Tolerances and Ranges of Use

Calibration curves shall be used to define the range of use and tolerances for the HPLC. The correlation coefficient (R^2) value of the calibration curve shall define the tolerance. In order for the calibration curve to be

acceptable, the R^2 must be equal to or greater than 0.998.

3.4.10 M&TE Storage and Handling

M&TE shall not be handled in a manner that adversely affects its current or future performance. M&TE shall be used in laboratory environments, and stored at room temperature.

3.4.11 Calibration Documentation

In accordance with YAP-12.3Q, staff members shall document the M&TE calibration on the M&TE Calibration Documentation Form (Attachment 2).

Calibration is required each day samples are analyzed, and calibration is an integral part of the measurement procedure. A calibration sticker containing the following information shall be affixed to the instrument.

Calibration
By: LBNL staff following the TIP for calibration.
This instrument shall be calibrated each day samples are analyzed.
Instrument S/N:

Copies of the calibration results shall be provided to the LBNL M&TE Custodian to update the M&TE list as per YAP-12.3Q.

3.4.12 Controls for Out-of-Calibration Conditions

If any out-of-calibration conditions (as described in YAP-12.3Q) are determined to exist for the M&TE item (e.g., instrument produces results known to be in error), the instrument shall have an out-of-service tag applied indicating that it is not to be used and, when possible, the instrument shall be moved to a segregated "out-of-service" area.

The above conditions shall be documented by using the M&TE Out of Calibration Report (OCR) in accordance with the instructions provided in YAP-12.3Q. If it is determined that the data are impacted, a Nonconformance Report (NCR) shall be initiated in accordance with YAP-15.1Q, *Control of Nonconformances*.

3.4.13 Recalibration When Updates to Software Contained Affects Calibration

All software used in M&TE is integral to the M&TE. Software updates will not affect the previous calibrations as calibration is required each time

samples are analyzed.

3.4.14 Usage of M&TE

Staff Members shall document each usage of the equipment in the scientific notebook (containing the same information as described in YAP-12.3Q), or the M&TE Standard Usage Log as described in YAP-12.3Q and file the Usage Log in the Equipment Logbook or scientific notebook).

3.5 Potential Sources of Error and Uncertainty

The following potential sources of error and uncertainty may exist:

- poor preparation of standards,
- gas in solvents,
- particulates in the samples,
- improper storage of samples such that the constituents sorb to container walls, degrade or are otherwise compromised,
- temperature difference between samples, and
- presence of interfering constituents in the samples that is not present in the calibration standards.

4. RECORDS

4.1 Lifetime

Records generated as a result of this TIP are entries in:

- Scientific notebooks or attachments to such notebooks,
- Equipment Logbooks (including M&TE Standard Usage Log, if applicable),
- M&TE Out of Calibration Report, if applicable.

4.2 Non-Permanent

None

4.3 Controlled Documents

This Technical Implementing Procedure

4.4 Records Center Documents

Records associated with this procedure shall be submitted to the Records Coordinator for submittal to the Records Processing Center (RPC) in accordance with AP-17.1Q, *Record Source Responsibility for Inclusionary Records*.

5. RESPONSIBILITIES

5.1 The Principal Investigator (PI) is responsible for assuring full compliance with this procedure and providing training thereof. The PI is responsible for overseeing and coordinating the preparation, review, distribution, revision, and recommending rescission of the TIP.

5.2 Staff Members are responsible for following this procedure and turning over related documentation to the Records Coordinator for submittal to the RPC in accordance with AP-17.1Q. Related data shall be turned over to Technical Data Coordinator for entry into the YMP Technical Database Management System (TDMS) in accordance with YMP-LBNL-QIP-SIII.3, *Submitting Key Data to the Yucca Mountain Project Office*.

6. ACRONYMS AND DEFINITIONS

6.1 Acronyms

ACS	American Chemical Society
AFT	Ambient Field Testing
AP	OCRWM Administrative Procedure
EA	Engineering Assurance
HPLC	High Performance Liquid Chromatography
LBNL	Lawrence Berkeley National Laboratory
LC	Liquid Chromatography
M&TE	Measuring and Test Equipment
MSDS	Material Safety Data Sheet
NCR	Nonconformance Report
NIST	National Institute of Standards and Technology

OCR	Out of Calibration Report
OCRWM	Office of Civilian Radioactive Waste Management
OQA	Office of Quality Assurance
PI	Principal Investigator
QIP	Quality Implementing Procedure
RPC	Records Processing Center
SMF	Sample Management Facility
TDMS	Technical Data Management System
TIP	Technical Implementing Procedure
UV-VIS	Ultraviolet-visible
YAP	YMP Administrative Procedure
YMP	Yucca Mountain Site Characterization Project

6.2 Definitions

Staff Member: Any scientist, engineer, research or technical associate, technician, or student research assistant performing quality-affecting work for YMP-LBNL.

Technical Implementing Procedure: Each TIP describes YMP-LBNL technical tasks that (1) are repetitive, and (2) are standardized.

7. REFERENCES

AP-17.1Q, *Record Source Responsibility for Inclusionary Records*

AP-2.21Q, *Quality Determinations and Planning for Scientific, Engineering and Regulatory Compliance Activities*

AP-SIII.1Q, *Scientific Notebooks*

AP-SIII.3Q, *Submittal and Incorporation of Data to the Technical Data Management System*

DOE/RW-0333P, *Quality Assurance Requirements and Description*

Reagent Chemicals: American Chemical Society Specifications. 8th edition, official from April 1, 1993. American Chemical Society, Washington, DC, 1993.

YAP-12.3Q, *Control of Measuring and Test Equipment and Calibration Standards*

YAP-15.1Q, *Control of Nonconformances*

YAP-SII.1Q, *Submittal, Review, and Approval of Requests for Yucca Mountain Site Characterization Project Geologic Specimens*

YMP-LBNL-QIP-5.2, *Preparing Development Plans & Quality/Technical Implementing Procedures*

YMP-LBNL-QIP-6.0, *Document Control*

YMP-LBNL-QIP-SII.0, *Documenting Sample Control*

YMP-LBNL-TIP / AFT-1.0, *Balance Calibration*

8. ATTACHMENTS

Attachment 1: M&TE Justification Form.

Attachment 2: M&TE Calibration Documentation Form.

9. REVISION HISTORY

03 / 26 / 99 - Revision 0, Modification 0:

Initial issue.

08 / 18 / 00 – Revision 1, Modification 0:

Revised the procedure to meet YAP-12.3Q requirements and incorporate references to other applicable APs and YAPs.

Removed Ion Chromatography measurements and made it a separate TIP (i.e., AFT / TIP 12.0).

10. APPROVAL

Signature on File

Preparer: Qinhong (Max) Hu Date:

Signature on File

Technical Review: Timothy Kneafsey Date:

Signature on File

Technical Review: Peter Persoff Date:

Signature on File

EA Reviewer: Vivi Fissekidou Date:

Signature on File

OQA Concurrence: Stephen Harris Date:

Signature on File

Principal Investigator: Joseph S.Y. Wang Date:

Signature on File

Project Manager: Gudmundur S. Bodvarsson Date:

YMP-335-R0
07/30/1999

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT MEASURING AND TEST EQUIPMENT JUSTIFICATION

QA:
Page:____ Of:____

1. M&TE ID No.:	2. M&TE Type:

3. Initiator Name:	4. Date:	5. Responsible Manager or Principle Investigator:

6. Justification:

7. Approved By:

Responsible Manager or Principle Investigator: _____ Date: _____
Printed Name

_____
Signature

M&TE Calibration Documentation Form

a) M&TE description	**b) M&TE unique identification**	**c) Calibration date and time (if applicable)**
d) Person performing calibrations		**e) M&TE condition (as-found)** Working _____ Not working _____
f) Calibration procedure (including revision level)		**g) Calibration standards used**
h) Location of calibration data YMP-LBNL-_____ Page(s):		**i) Location of calibration results** YMP-LBNL-_____ Page(s):
j) Specified range and tolerances		
k) Statement of acceptability including acceptability of range and tolerances Range acceptable Yes _____, No _____ Tolerance acceptable Yes _____, No _____ Calibration acceptable Yes _____, No _____ Comments:		
l) Re-calibration due date or calibration interval/frequency		**m) Reference to actions taken with out-of-calibration or non conforming M&TE, including evaluation results, as appropriate** YMP-LBNL-_____ Page(s):
n) Comments		

Signature Date